Briek Making

by

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Foreword

In this manual the method of making good and strong bricks at low cost has been described. The manufacture of cheap and good bricks depends on two things. Firstly obtaining suitable quality of soil by tests and investigations and improving the quality of soil. By the tests given in this manual it is very easy to select suitable quality of soil and to effect improvements in it.

The second important thing is burning bricks properly. For making good bricks at cheap cost, according to the requirements, design of big and small, temporary and permanent kilns, and the method of loading and burning them have been fully described. For manufacturing bricks on a large scale modern kilns have been suggested and their description given.

Other useful information such as suggestions for making the soil suitable for brick making, method of making good bricks from black cotton soil, description of machines for brick making etc. given in the book, it is hoped, would prove to be very useful in bringing about improvement in brick manufacture.

This manual has been written primarily for the use of villagers so that they could make cheap and good bricks themselves. For the improvement of rural housing situation, the importance of bricks is very great; also in the construction field, brick has a special place of importance being one of the principal building materials. It is, therefore, necessary to give attention to improvement in brick manufacture. In this direction if this manual proves to be of use, then the purpose of this manual would be well served. I trust that the method of making cheap and good bricks which has been described in this manual, in simple language with illustrations, would make this book popular.

C. P. MALIK,
Director, National Buildings Organisation
& Regional Housing Centre,

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SELECTION OF SITE FOR BRICK MAKING

Such a site should be selected for the manufacture of bricks where suitable quality of soil is available in sufficient quantity. Mostly such sites are found along the river banks, in the valleys or in the plains where soil brought by the river gets deposited.

First of all from experience and investigation of the site the suitability of the available soil is estimated. And when manufacturing of bricks is to be done on a large scale it is necessary to carry out scientific tests to determine the suitability of the soil.

At the same time it should be kept in mind that the soil for brick making should be easily available; otherwise unnecessary labour and cost for digging and transportation of the soil would be involved.

Besides the soil, easy availabili other materials is also necessary for t manufacture.

Generally for making the soil suitable for brick making, certain materials are required to be mixed with the soil and therefore the availability of such materials near the site for brick making is of great importance. It is very necessary that water and fuel like coal or wood should be easily available in sufficient quantities.

Preparation of site for brick making

Site for brick making should be levelled. When the ground is uneven there is a danger of the shape of bricks being bad.

When there is a danger of rain and flood water, there aroun the site small mud wall should be constructed.

At the site, there should not be any vegetation, plants or trees. If they are there, these should be dug out and remove

It would be better if the pits which are made due to the digging of the soil could be utilised for some purpose. Such pits when dug in the bed of a dam could increase its storage capacity and if these pits are near the fields, then these could be used as manure pits.

By digging the soil from the higher portion of the ground, the ground could also be levelled.

TEST FOR DETERMINING THE SUITABILITY OF BRICK EARTH

Generally the soil which contains four parts of clay and one part of sand is considered to be suitable for brick making. Experienced people are able to determine the suitability of the soil by looking at the soil and by rubbing it in the hand.

The scientific method for testing the suitability of the soil is as follows :—

Collect samples of soil from different places from the site selected for brick making. The samples are either taken from the surface or by removing some layers of top soils. If 15 litres of soil ($\frac{1}{2}$ cu. ft.) is taken for each sample then the work of testing is done very conveniently. For identification, the bricks made from each sample and the respective place from which the sample has been collected should be similarly marked.

For determining the suitability of the soil, the following four tests should be made :

(1) *Test for the consistency of the soil :* By drying the soil in the air, the required consistency is determined.

(2) *Test to determine the moulding properties of the soil :* From the soil which has been found successful in the above test, bricks of correct size are moulded.

(3) *Determining the shrinkage and deformation if any, in the bricks after burning :* The sample bricks are burnt after which the deformity and shrinkage are determined.

(4) *Test for determining the strength and quality of the bricks :* Find out the quality and strength of the brick.

DESCRIPTION OF THE TESTS

First Test : Soil and its mixing

From this test it is found as to how much sand and water should be added to the soil so that proper plasticity may be developed in the soil. It should be remembered that the proportion of sand and water should be the same and for this purpose the proportion should be decided in figures. To find out the correct proportion in every litre of the soil sample, water and sand should be added. From test and experience the quantity of water and sand required for developing correct plasticity could be very quickly estimated.

The above test can be divided into the following steps—

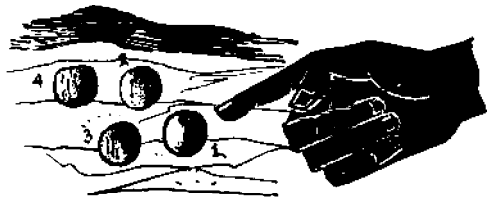
(*i*) First of all remove stones, *kankar* etc., which cannot be grounded.

(*ii*) After this, grind every soil sample well to a fine powder.

(*iii*) Then mix sufficient quantity of water gradually with the soil so that it becomes plastic and could be moulded with hands. So long as the soil does not become plastic, water should be added in small quantities and the soil mixed with hands. It must be remembered that not more than the required quantity of water should be added ; otherwise it would not be possible to mould bricks.

(*iv*) From this plastic soil, take a handful of soil sample and add very little water to it and form a ball by pressing it. Keep this ball on the ground in the sun for drying.

(*v*) When the ball has dried then find out by inspection if the ball has lost its shape and examine the cracks which have occurred on the surface of the ball.



(1) The ball which does not get deformed on drying and which shows very little cracks on its surface, shows that the soil used for it is suitable for brick making.

(2) The ball which gets deformed on drying and crumbles easily shows that the soil from which it is made contains more of sand than required. From such soil, bricks cannot be moulded.

If some soil which contains less sand is available then by mixing this soil, the above soil could be made suitable for brick moulding. It is far easier to add sand to the soil which contains less of sand in order to make it suitable than to mix two types of soils for the purpose.

(3) The soil of the ball which after drying has become hard and shows wide cracks on the surface, contains less of sand. Such a soil could be improved by adding the required quantity of sand. The easiest way for this is to add a small quantity of sand gradually and form balls which should be examined after drying to know the suitable sand proportion.

(*vi*) By mixing different proportions of the two types of soils, form small balls and keep them for drying. After drying, examine the shape of the balls and the cracks formed on the

surface. The ball which shows least deformity and cracks has the correct soil proportion for brick moulding.

Second Test : Testing the soil for moulding

It is not necessary that the soil which has been found to be successful in the first test may be good for brick moulding.

Generally for moulding of the bricks properly some additional quantity of water is required to be added.

(*i*) The soil, used for the ball which after drying does not lose shape and shows very little cracks is considered to be suitable for the second test. In the mixture the proportion of water and sand should be the same as the one used for making the ball.

(*ii*) The soil mixture should be kneaded very well. If the soil mass has mixed properly then it would be possible to form thick threads from the soil.

(*iii*) This mass of soil should be put into the mould and brick moulded. The brick should be examined to find out whether it is properly moulded.

(*iv*) If the edges and corners of the moulded brick are not well formed then the mixture contains less quantity of water. In this situation, by adding more quantity of water the soil mix could be made suitable for brick moulding. By adding water gradually to the mix, brick should be moulded and this process should be repeated until well formed bricks could be moulded.

(*v*) The same process should be repeated with the samples of soils which have been found to be successful in the 1st test.

(*vi*) The bricks which have been made from the same soil-sand-and-water mix should be given similar mark.

(*vii*) Leave all moulded bricks for drying on the ground for four days.

Third Test : Determining the shrinkage and deformation if any in the bricks after burning

From this test the extent of deformation and shrinkage that occurs to the sample brick is determined. The test is done as follows :

(1) The sample bricks should be burnt in the ordinary potter kiln for three days and four nights, until the bricks become red hot. As a matter of fact the time for burning of the bricks depends upon the size and shape of the kiln ; but normally it is two times the time taken for baking an earthen pot.

(2) While setting the bricks in the kiln it should be remembered that the bricks should be so arranged that some space is left in between them so that they may burn properly.

(3) The sample bricks should be put here and there in such a manner that all the bricks from the same sample may not get over burnt.

(4) Great care should be taken while arranging the bricks in the kiln.

(5) When the bricks have been burnt, allow all the bricks to remain in a lot until all of them get cooled.

(6) When the bricks have moulded, remove them from the kiln and these should now be examined for shrinkage and deformation.

(7) The bricks which have lost their shape and have completely been deformed should be sorted out. Those bricks which have shrunk evenly and do not show any bad effect due to burning should be selected. These should be tested for strength and quality.

Fourth Test : Test for determining the strength and quality of the bricks

The strength of the bricks should be determined in the following manner.

(1) The soundness of the brick is found out by striking the flat surface of a brick with that of another. If the sound produced is a metallic one, then the bricks are of good quality. If this sound is dull then the bricks are not of good quality and the burning has not been proper.

(2) The strength of the bricks is also measured by soaking them in water. For this keep the brick immersed in water for 24 hours. After this examine them.

The bricks which become soft by immersing in water should be broken and again immersed in water after which the extent of their becoming soft should be found out.

Good bricks do not absorb more than $\frac{1}{8}$th to $\frac{1}{6}$th of their own weight of water when immersed in water for 24 hours.

(3) By dropping on the sample bricks a wooden log from a height of 4 inch (10 cm.) the strength of the brick is determined. By dropping the log of wood from different heights the extra strength of the brick samples could also be found out.

The compressive strength of very good brick is not less than 1,000 lbs. per sq. inch (70 kg. cm. sq.).

Some useful information for carrying out the tests

While preparing the soil for the test the following points should be kept in mind.

(1) It is better if the sample bricks could be burnt in bigger kilns. By doing so the burning will be proper and the results more satisfactory.

(2) It is better to have a heavy and dense soil sample.

(3) If the burnt bricks break easily then they are deficient in two respects. They are either not properly burnt or the soil from which they have been made contains too much of sand.

(4) The method of making the bricks which have been found suitable after successfully carrying out the four tests should be noted so that the same method could be adopted for making bricks on a large scale.

PREPARATION OF THE SOIL FOR BRICK MAKING

First of all the soil for brick making should be dug and brought to the site where bricks are to be moulded and burnt.

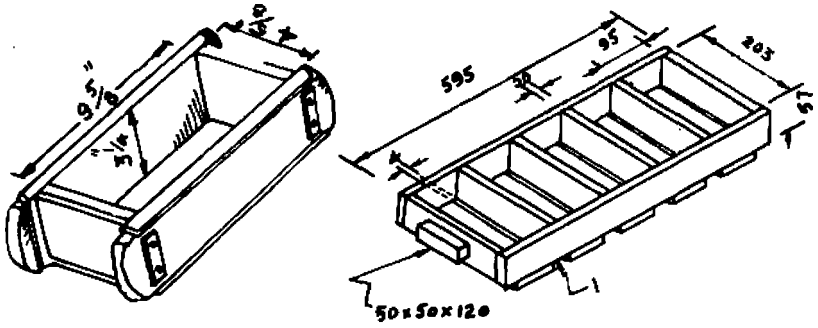
Generally after sprinkling some water on the heap of the soil it is left over for some days. After this necessary quantity of sand, if required, and water should be mixed with the heap of the soil very well. The quantities of sand and water required for mixing are found from the first test which has been described earlier.

The mixing of the soil is done by kneading and with the help of spades. With the help of animals also the mixing could be done. When the brick manufacture is to be done on a large scale then the pugging of the soil should also be done with the help of machines.

(*see* page 27).

The object of pugging is that the soil may become homogeneous and develop required plasticity. It is very necessary that the soil must be mixed very thoroughly.

BRICK MOULDS



From the moulds shown above bricks are cast. Generally the mould is made of wood. Metal moulds can also be used.

With the help of new moulds shown on the right, five bricks could be moulded simultaneously and quickly. The shape and size of the mould are shown in the above sketch. For moulding bricks of a particular size, mould of the required size is prepared.

Some machines are also used for moulding bricks. The details and sketches of such machines are given on pages 28-29.

METHOD OF MOULDING BRICKS

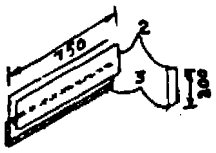
(1) Before moulding the bricks, the mould should be dipped in water for some time and after that sprinkle some dry sand all

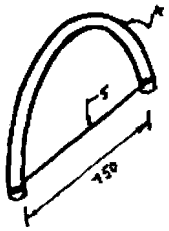
over the inside of the mould. It should be remembered that the sand should be sprinkled very well in the inside surface of the mould so that bricks do not stick to the mould.

(2) Take a lump of well mixed soil, the volume of which should be little more than that of the brick. This is done because wet soil shrinks on drying and burning. This lump should be shaped in hand to the size and shape of the brick.

(3) After this it should be rolled in sand and with a jerk the lump is thrown into the mould in such a manner that the mould is completely filled with the soil. As far as possible no extra soil should be required to fill the mould. To fill the mould properly a wet soil or a lump should be pressed with the help of thumb.

(4) The surplus soil should be scrapped off and the top surface levelled. For scrapping metal plates are used. Normally a wire is used for removing the extra soil in the mould. (*See sketches* below).



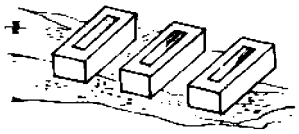


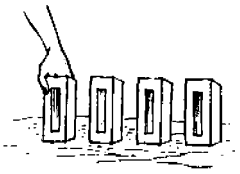
(5) Then with the help of the handle which is attached to the mould the mould is lifted up and struck with a hard thing so that by the jerk the brick in the mould may get detached from it.

(6) On a level ground sprinkle some sand so that bricks do not stick to the ground. Now the mould is turned over on the ground and is then lifted leaving the brick to dry. Often on a metal plate the mould is turned over to separate it from the brick. The brick is then taken and kept at the place for drying.

DRYING OF BRICKS

(1) For drying, the bricks should be arranged in a row. By keeping the bricks at equal distances they receive air and sun for proper drying.





(2) It is necessary to protect bricks from dampness and rain while drying and for this, if required, sheds are also constructed.

(3) The bricks should be dried in the sun till they become sufficiently hard. When the bricks on drying become quite strong, then they are ready for burning in the kilns. For complete drying of bricks in the sun it takes about eight days.

(4) When the bricks are capable of being lifted then these should be arranged in a heap so that they could dry more.

(5) After drying, the bricks are taken to the kiln and arranged in it for burning. It is necessary to ensure that the bricks have dried well ; otherwise the moisture of the damp bricks is driven out when the bricks are burnt and it is harmful to the top surface of the dry bricks, thus causing defect in the burnt products.

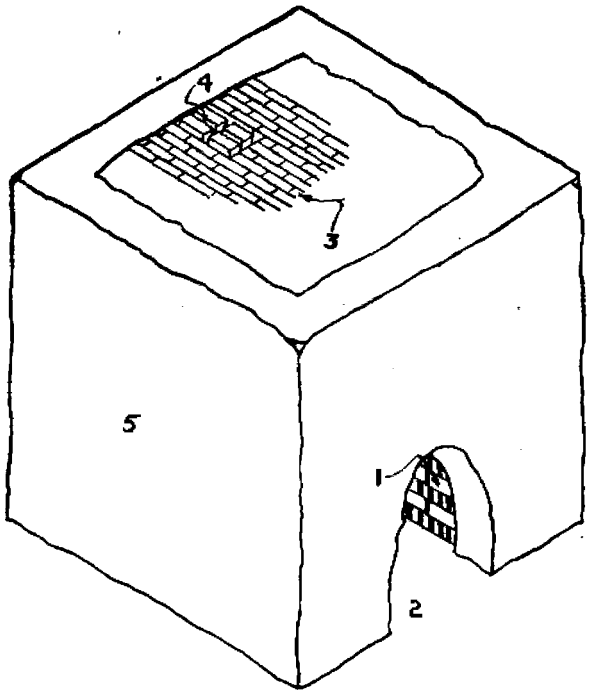
BURNING OF BRICKS

Method of construction and firing of brick kilns

1. Temporary brick kilns

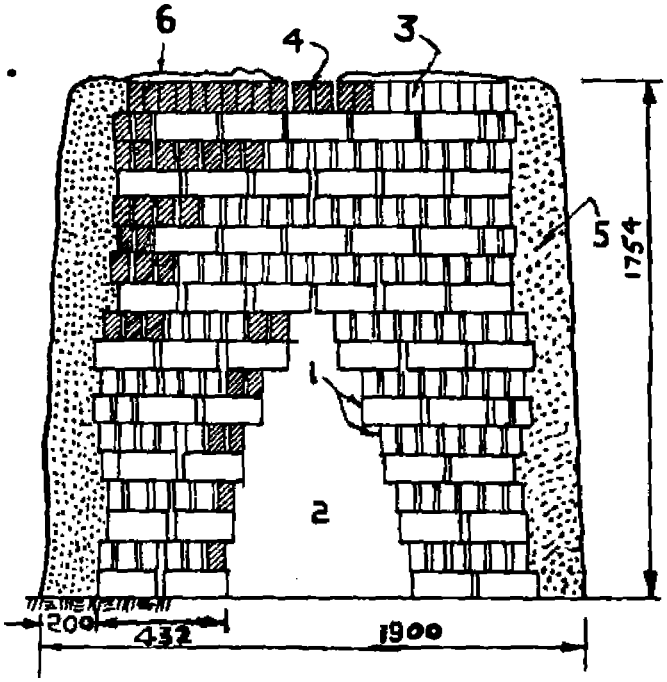
The temporary kiln is formed out of the bricks which are to be burnt in the kiln. Such a kiln can be very quickly made. With a temporary kiln, about 1800 bricks could be burnt at one time. By reducing the size of the kiln less number of bricks could be burnt in the kiln.

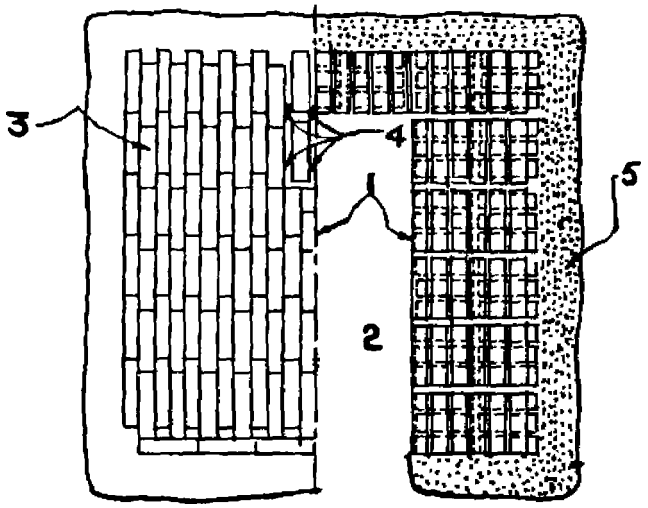
The method of construction of the temporary kiln could be understood with the help of the sketches given below.



Complete view of temporary kiln

Half cross-sectional elevation of the kiln





Half sectional plan

1. Bricks which are to be burnt
2. Place for fire
3. Closely packed bricks to form roof of kiln
4. Air space between four bricks
5. Layer of soil over the walls of the kiln
6. Layer of soil on the roof of the kiln

1. First of all separate out a lot of 1800 dry bricks.

2. Now arrange the bricks as shown in the sketch. In one row set the bricks lengthwise and in the other keep them on their edges (1). This order should be repeated in alternate rows.

3. The bricks should be arranged in such a manner that space for burning fire is left in the middle of the kiln (2).

4. The topmost bricks in the kiln should be kept on their edges very close to each other so that roof of the kiln is formed (3). In the roof so formed leave small spaces (4) for the burning of fire.

5. The outside of the kiln formed with the bricks to be burnt should then be covered with a layer of soil 200 mm. (8 in.) thick in order to cover the bricks (5). It should be remembered that the kiln should not be covered with a layer of soil on its roof at this stage.

6. When the kiln would be fired then with the heat produced the dampness of the bricks would be driven out and the bricks would start shrinking. Therefore the roof of the kiln should not be covered with a layer of soil. When the bricks forming the roof of the kiln have shrunk then it is known that the dampness of the bricks has been driven out.

7. Now cover the roof of the kiln with a layer of soil of 25 mm. thickness (1 inch) (6). By this the heat of the kiln is conserved and the required temperature inside the kiln for burning the bricks is developed.

8. It should be remembered that for burning of the fires, spaces (4) must be left in the roof of the kiln.

Method of burning the kiln

After the construction of the kiln the space which is left in the middle of the kiln should be filled from both sides with dry wooden logs so that it is half full with fuel. After this the fire shoud be ignited. The fire should be slow and dull so long as the dampness of the bricks is not driven out. After covering the roof of the kiln with a layer of 25 mm. of soil, more fuel should be added and the fire should be burnt very briskly.

The fire should be kept burning in this manner for about 10 days. After 10 days scratch out the soil covering from the side at some place and see if the bricks have become strong and have burnt properly. If the bricks have not become strong then continue firing them.

After proper burning of the bricks allow the kiln to cool. On examining the burnt bricks it will be found that about 15-20 per cent bricks have either broken or are not fit for use.

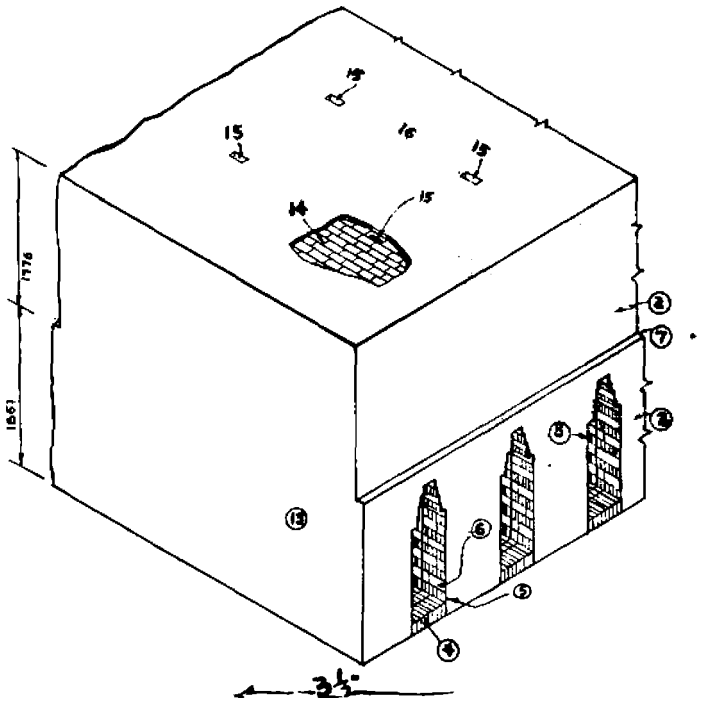
2. Permanent brick kilns

The method of constructing permanent kilns would be clear from the sketches given. The advantage of a permanent kiln is that several loads of bricks could be burnt in the same kiln. This is not possible in the case of ordinary temporary kilns. Another advantage is that the bricks could be set into the kiln very quickly as two of its walls are permanent. Permanent kilns are made only at such places which have been selected on somewhat permanent basis for brick manufacturing. Depending on the size of the kiln definite number of bricks could be burnt at a time.

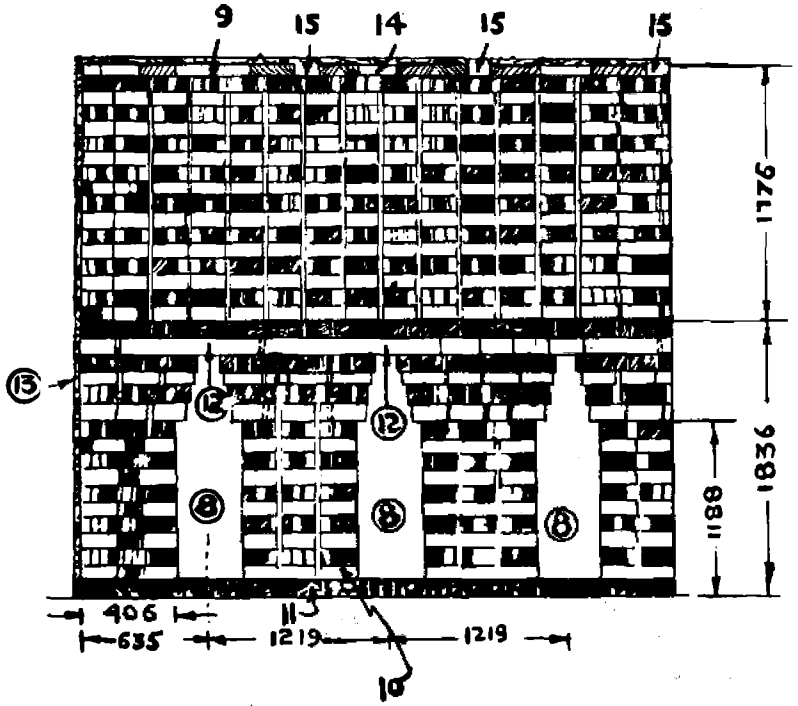
The two walls of the kiln which are permanent ones are made of burnt bricks and mud mortar. The rest of the walls of the kilns are constructed with the bricks which are to be burnt as in the case of temporary kilns. In the kiln, the sketch of which is given here, about 16,000 bricks could be burnt at a time but when necessary, by decreasing the dimensions of the kiln lesser number of bricks could also be burnt. In any case burning of less than 10,000 bricks in permanent kilns does not prove to be economical.

Location of the Kiln and the Method of its Construction

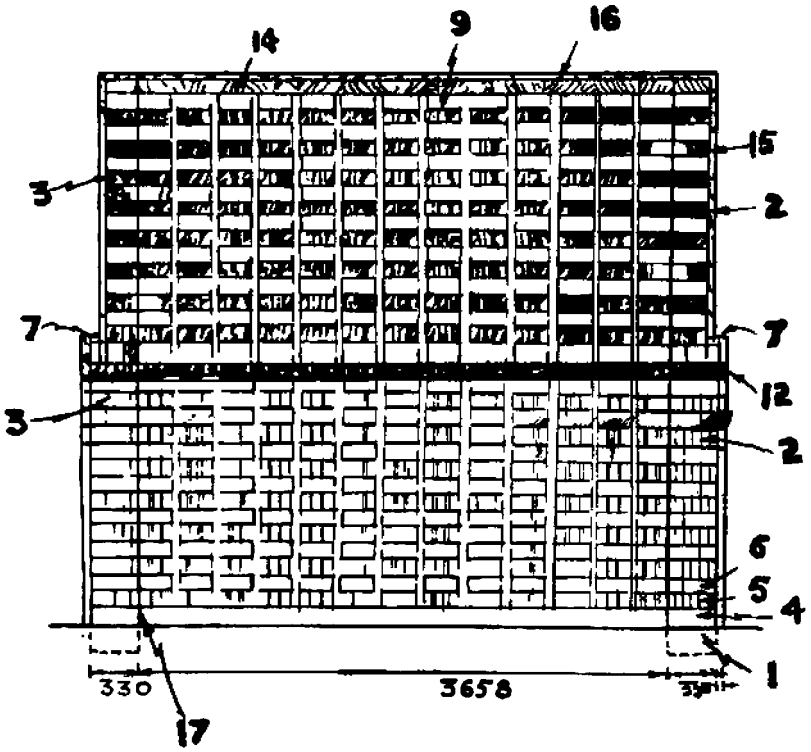
A site which is even and dry should be selected for the construction of the permanent brick kilns. The trench for the kiln



Complete view of the permanent kiln



Sectional front elevation of the kiln

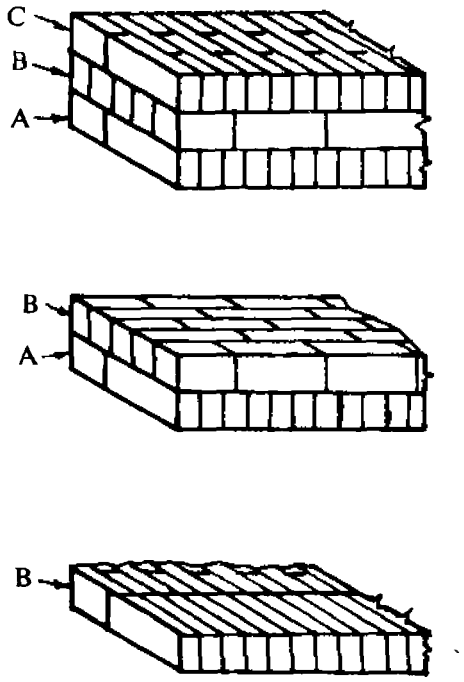


Sectional view of the kiln

Fig. (1) Foundation ; (2) The front permanent wall which is 330 mm. thick up to height of 1836 mm. and rest of which is 230 mm. thick—total height of the wall 3708 mm. (12 ft.) ; (3) The back permanent wall is constructed in the similar manner as the front wall ; (4) As shown in sketch 'A' a first layer of the brick in wall ; (5) As shown in sketch 'B' the second layer of bricks in wall ; (6) As shown in sketch 'C' the third layer of bricks in the wall ; (7) From here the thickness of the wall is 230 mm. ; (8) Space for supply of fuel in the front and the back walls ; (9) The heap of bricks which are to be arranged in the kiln for burning ; (10) The order of arranging first row of bricks in the heap ; (11) The order of arranging second row of bricks in the heap ; (12) The arrangement of bricks to form the heap up to top of the kiln and for forming the roof of the kiln ; (13) Cover of mud on the walls ; (14) Roof of the kiln formed by closely set bricks ; (15) Holes for flue in the roof of the kilns ; (16) Cover of mud on the roof ; (17) The inside surface of the kiln.

should be dug at such a place where the front and the back walls of the kiln could be constructed. This trench should be 3,708 mm. (12 ft.) long and 300 mm. (1 ft.) deep. It is better if the trenches are dug deep so that hard soil is met with and the foundations of the permanent walls of the kiln could be strong. The front and the back walls of the kiln are made of the same shape and dimension. The thickness of the permanent walls should be 330 mm. (13 inches) upto 1,836 mm. (6 ft.) height. The lower portions of the walls should be in the trench and if some space is left around, it should be filled with the soil and rammed properly. The lower portion of the wall which is below the ground level should be made of burnt bricks and the part of the wall above the ground level could be made of unburnt bricks and mud mortar. When the walls had been constructed up to the height of 1,836 mm. then the thickness of the rest should be reduced by 100 mm. (4 inches) *i.e.*, the thickness should be reduced from 330 to 230 mm. (9 inches). In this manner the top portions of the walls are constructed thinner than their lower portions. By making the lower portions thicker, the walls are able to withstand the pressure of the bricks and by keeping the upper portions thinner the load on the wall is reduced. The upper portion of the wall which is 230 mm. thick is further raised to a height of 1,776 mm. ($5\frac{3}{4}$ ft.).

The method of construction of this wall is very important. The first layer of the bricks in the wall is laid on their edges as shown in sketch A. After this apply on it a layer of mud mortar and lay the second layer of bricks (5). Again apply mud mortar over it and lay the third layer of bricks as shown in sketch B. In this way as shown in (6) a layer of mud mortar and another of brick are laid. When the thickness of the wall equals the length of the brick then half bricks are used. The method of laying the bricks is shown in the figure.



Method of laying bricks to form the front and back walls of the permanent kiln

For supply of fuel in these two walls (as shown in the sketch) at least three spaces should be left. These spaces should be made in the form of tunnels running through the kiln.

Method of Loading the Brick Kilns

When the front and the back walls of the kilns have been constructed, brick paving is done between these walls to form the floor of the kilns. For making the floor the bricks should be set very closely to each other and mud mortar should be used. Unburnt bricks could be used for making the floor of the

kiln. As shown at (9) in the figure unburnt bricks are arranged in square heaps in the kiln. The square heaps of the bricks are of three bricks length. These are raised from the floor up to the top of the kiln.

For the first loading of the kiln three bricks are laid (10) on their edges with their faces parallel to the walls. Behind these at a distance of 16 mm. ($\frac{5}{8}$th inch) another row of bricks is laid in a similar manner. After this three bricks are laid so that their edges are parallel to the walls at a distance of 16 mm. to each other. Like this the two rows of bricks are laid at right angles. In this order the bricks are laid to form the heap up to the top of the kiln. In every heap a space of 16 mm. should be left so that the bricks could be heated from all sides.

While forming the heaps of bricks in the kiln three spaces (8) should be left for the fuel—a space of 457 mm. width (17 inches) and 1470 mm. (5 ft.) height should be left. When the bricks have been arranged in the kiln up to the height of 1470 mm. then the roof of the kiln (12) is formed, by filling in a solid layer of bricks in between the walls. By forming the roof of the kiln, first the temperature of the kiln is reduced a little and bricks are also burnt well. On shrinking of the bricks some cracks are formed in them and the heat coming out through these helps in burning the bricks. The roof of the kiln is covered with wet soil so that the heat of the kiln may not be wasted and bricks are burnt well. Now a layer of 15 to 20 mm. thickness of wet soil is pasted on all sides of the kiln (13). Like this the kiln is prepared which is ready for firing.

Burning the Kiln

First of all through the front and the back walls fuel is filled in the kiln. In the beginning the fires are kept dull so that the dampness of the unburnt bricks could be extricated in the form of steam. In the day time the dampness of the bricks in the form of steam is not visible, but at night it is clearly visible. For two days and two nights the dampness of the bricks should be allowed to go off in the form of steam. The steam as it comes off dampens the bricks which form the roof of the kiln. When the bricks

forming the roof of the kiln have dried then the roof should be covered with a paste of wet soil completely, but in the roof four spaces must be kept open for the flue (15).

Before pasting the soil on the roof, bricks standing on edges should be laid flat (14) so that they do not crack. For covering the roof of the kiln, a paste of soil of thickness of 15 mm. is enough (16). After covering the roof the intensity of fire should be increased.

With the increase of temperature in the kiln, the bricks shrink and the roof starts sinking a little. It should be kept in mind that the roof should not be allowed to sink from here and there. Where there is more of heat there the roof sinks. For decreasing the temperature inside the kiln around that spot, the hole left for flue in the roof near to it should be closed by putting a brick over it and covering it with a paste of soil. By doing so the temperature round that spot is reduced and the roof there stops sinking further. Due to loss of heat at some places the roof does not sink. In such circumstances remove one brick from the roof of the kiln to provide the hole for the flue. By doing so that part of the roof gets more of heat and so it sinks. In this manner every effort should be made to keep the entire roof at the same level.

Ordinarily bricks are burnt in a period of seven days. As far as possible the temperature of the kiln should be kept constant. For this the quantity of fuel required is increased or decreased as the case may be and the effort is made to keep the roof of the kiln at the same level as mentioned above.

When the bricks have burnt the kiln is left to cool down and this takes about three to four days.

When the kiln is cooled bricks are removed from it. The burnt bricks which have broken or badly deformed or have clogged to each other should be sorted out. The rest of the bricks could be used for construction.

When the burnt bricks have been completely removed from the kiln, the permanent wall of the kiln and the floor are left as such. For reusing the kiln a fresh load of unburnt bricks is put into the kiln and the process of burning is repeated.

SOME USEFUL INFORMATION

In the simple methods of brick making which have been described the following defects exist on account of which good quality bricks are not obtained and the average cost of brick is high. The methods of removing these defects are described below.

(1) By using unsuitable quality of brick earth, good quality bricks are not obtained. Therefore it is very necessary that before manufacturing bricks, the soil should be scientifically tested to determine its suitability for brick making. On the basis of tests and investigations, necessary other materials could be added in required quantities to remove the defects of the soil.

(2) It is very necessary that in preparing the soil for brick moulding, pugging should be done very thoroughly. Due to insufficient pugging proper plasticity is not developed in the soil the result of which is that good bricks cannot be moulded. Also, due to this, defects are found in the burnt bricks.

(3) By the two causes mentioned above and by inadequate and improper drying of bricks, the bricks on drying get cracked and on burning are found to be defective.

(4) Great care should be exercised in burning the bricks. By unscientific burning the heat of the kiln is wasted very much and more fuel is consumed. Also if the temperature in the kiln is not kept even, then the bricks are either under burnt or over burnt. Such bricks are defective and cannot be used for good quality work.

SOME SUGGESTIONS FOR IMPROVEMENT OF THE SOIL

If possible the physical and chemical properties of the soil used for brick making should be determined by carrying out scientific tests in the laboratories. From the test the suitability of the soil for brick making is determined and it is also known if

for improvement of the soil, certain materials are required and if so the proportions in which they are to be added.

(1) From scientific investigations it has been found that the soil suitable for brick making should have the following :—

20 to 30 per cent clay
40 to 65 per cent silt
25 to 38 per cent liquid limit
7 to 13 per cent plasticity index
15 to 25 per cent volumetric shrinkage

(2) The black cotton soil which shrinks very much on drying and expands considerably when wetted could be made suitable for brick making by the addition of coal ash in certain proportions and by other methods. The Central Building Research Institute, Roorkee, the P.W.D. Research Institute, Lucknow and the Railway Testing and Research Centre, Lucknow, have successfully carried out investigations for making the black cotton soil suitable for brick making.

(3) If the soil for brick making contains lime nodules then the bricks made of such soils get cracked which is called lime bursting. For checking lime bursting in bricks, a solution of 0.5 to 0.75 per cent sodium or potassium chloride (table salt) in water and 5 to 10 per cent of coal ash should be added to the soil. The bricks formed from this soil should be burnt under light fire. The burnt bricks on cooling should be dipped in water. This further checks lime bursting.

METHOD OF MAKING GOOD BRICKS FROM BLACK COTTON SOIL

Black cotton soil is found extensively in the Central and Western parts of India. Because this soil is very plastic it is difficult to make good quality bricks from it. This soil shrinks very much and contains lime nodules which expand on burning causing

lime bursting in bricks. For these reasons difficulty is experienced in mixing and pugging of the soil. While moulding, the bricks made from such soils stick to the mould, crack on drying, and after that on burning bursting of lime nodules takes place. Therefore good and strong bricks from black cotton soil as such cannot be produced.

The black cotton soil could be made suitable for brick making in the following two ways :—

(*i*) By addition of 40 to 50 per cent coal ash with black cotton soil. The coal ash should be finely ground and should not contain unburnt carbon. Used coarse coal ash results in weak and porous brick.

(*ii*) By grinding and burning black cotton soil and then adding it in certain proportions with the unburnt black cotton soil good bricks could be formed. This is done in the following manner.

Dig the damp black cotton soil from a pit and spread it in a layer of 50 mm. (2 inches) thickness over the ground. After about 2 hours grind this soil in a grinding mill (garhat) ; about 275 to 325 litre (10 to 12 cu ft.) soil could be ground in this mill at a time. After grinding the soil for 40 minutes the soil is taken out from the grinding mill and screened. One labourer is required for driving the bullocks and two more labourers are required for putting the soil in the grinding mill and for removing it from there and for screening it.

About 1100 litres (40 cu. ft.) screened soil is taken and water is added to it in required quantities and lumps of soil are formed out of it. For this work two labourers are required. The lumps so formed are kept to dry for one night after which they are burnt in an ordinary potter kiln for 18 to 20 hours ; the temperature of the kiln is kept 500 to 600°C. The lumps should be kept in the kiln as long as the soil does not become red and when

water is sprinkled on the lumps they become soft. The burnt soil lumps should be removed from the kiln and ground in the grinding mill again. The burnt ground soil should then be screened and 25 to 30 per cent of this is added to the unburnt black cotton soil and mixed thoroughly. For mixing the burnt and unburnt soils form two separate heaps of the two types of soils and with the help of spade mix them well with each other. While mixing, it is important to remember that the two soils should be mixed very thoroughly. After this, water in sufficient quantity should be added to the mixture and pugging done by feet. Here also it should be remembered that pugging should be done very thoroughly. This mixture is then allowed to remain for one night.

Next day with the help of wooden moulds which have a metal lining inside, the bricks are moulded Burnt ground soil is used for sprinkling in the mould and for dusting the lump of the soil which is thrown into the mould to fill it and to form the brick. The bricks are burnt in kiln. The bricks after burning are arranged in a row and are then dipped into water completely to prevent lime bursting.

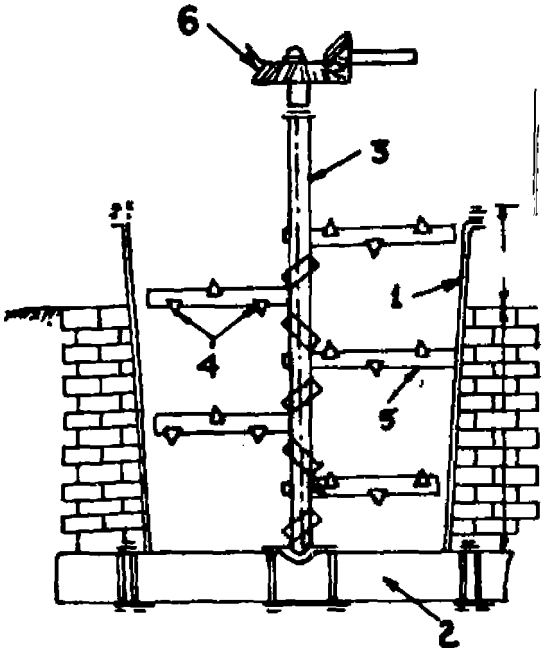
For making more than 5,000 bricks per day power driven grinding mill is required.

MACHINES FOR BRICK MAKING

Generally in our villages bricks are manufactured manually. But if to be manufactured on a large scale cheap and better bricks could be produced with the help of machines. Some such machines are described below.

(1) As has already been said it is very necessary that the pugging of the soil should be very thoroughly done so that good bricks could be moulded which on drying and burning do not lose their shape. Pugging of the soil could be done by a

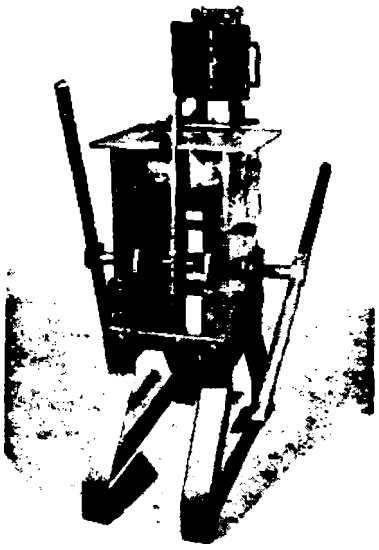
pug-mill. The sketch of the machine is given below. This machine is worked with the help of bullocks.



1. Steel tub
2. Bottom supporting plate
3. Shaft
4. Knife edges
5. Blades
6. Bewel gear

(2) Normally bricks are hand-moulded. For moulding of bricks quickly machines could also be used. One such machine has been evolved by the Central Building Research Institute, Roorkee. The machine is well built and strong and is worked

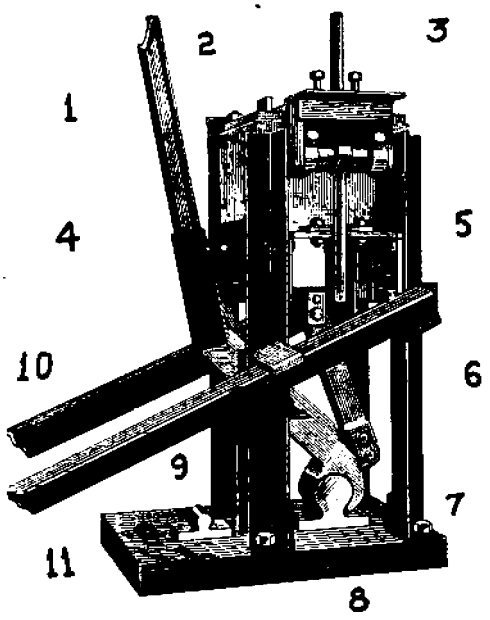
by hands. With this machine the work of brick moulding could be done continuously.



With this machine two bricks can be moulded at a time. Four men are required to work with the machine ; two of them operate the handle, the third one fills the mould and the fourth man removes the moulded bricks to the drying site. About 1500 bricks per day can be moulded with this machine.

(3) With another type of brick making machine it is said that about 2,000 bricks per day could be moulded. Five men are

required to operate this machine. The details of the machine could be seen below.



1. Main lever for pulling
2. Brick mould
3. Clamp
4. Plungers
5. Guide plate
6. Main link
7. Lock
8. Bearing
9. Fulcrum
10. Movable legs
11. Bottom planks

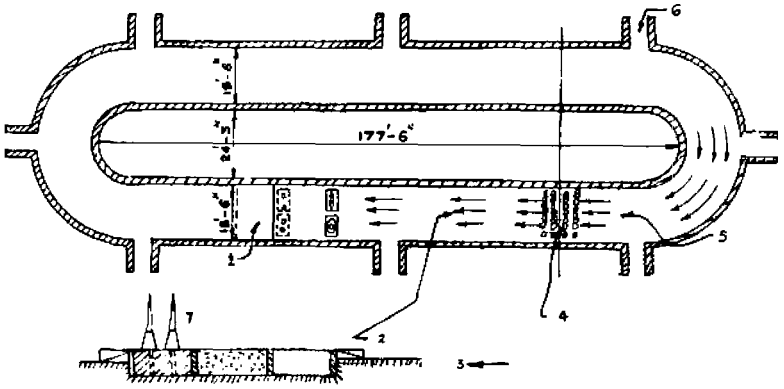
This machine is called Elson Block Master. It has a box-like metal mould in which the clay for brick making which has been thoroughly pugged is filled. By pressing the handle down and releasing the plunger which is connected with the lever the bricks are pressed. In this manner a total pressure of about 40,000 lbs. is applied on the bricks.

Different types of moulds could be used in this machine. With the help of this machine stabilised soil blocks could also be made. The legs and the handle of the machine could be removed and the machine could be transported very easily on the site for brick making. The weight of the machine is about 456 lbs.

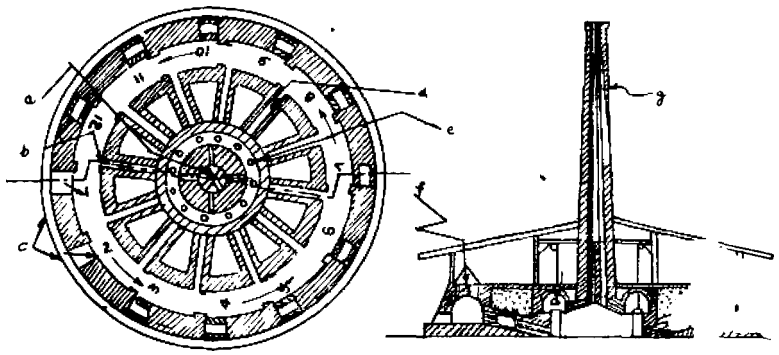
With the two machines mentioned above blocks can also be moulded. These soil blocks which are formed by the application of pressure in this machine could be used for construction without burning them.

MODERN PERMANENT BRICK KILNS

For carrying out brick manufacture on a permanent basis Bull's kiln and Hoffman kiln are used. These kilns are designed on scientific principles; as such the burning is done properly and the consumption of fuel is also less as the heat losses are minimised. Thus the cost of brick burning is also reduced. The shapes of these two types of brick kilns are given below.

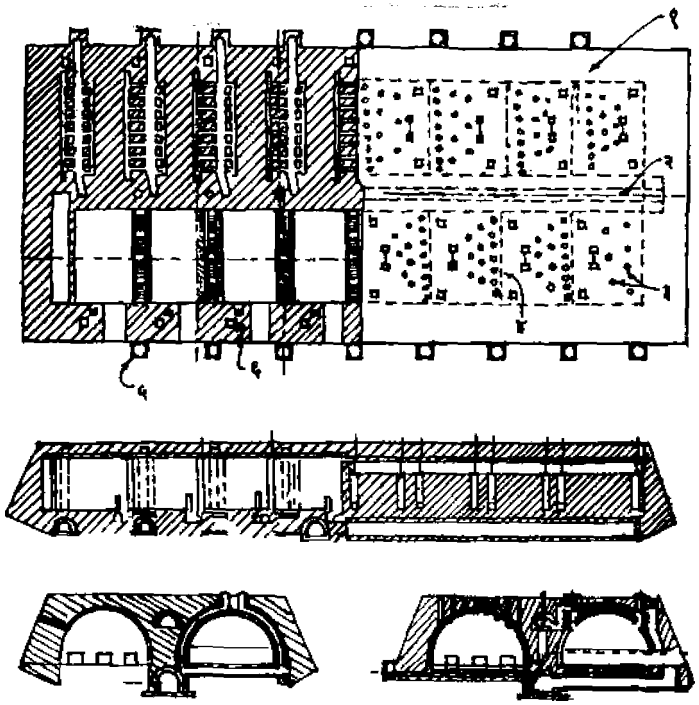


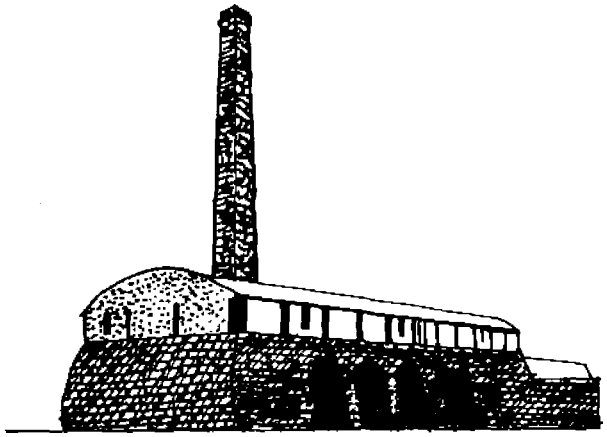
Bull's Kiln : 1. Damper. 2. Hot Bricks. 3. Direction of wind. 4. Hole for flue. 5. Cold Bricks. 6. Gate. 7. Chimney.



Hoffman's Kiln : a. Chimney. b. 0-12 chambers. c. Direction of wind. d. Flue. e. Damper gate. f. Hole for flue. g. Chimney.

Modern Hoffman's kiln.





1. Wall of the kiln
2. Middle partition wall
3. Space for filling the kiln with bricks
4. Parchment Division
5. Damper
6. *Flue holes*

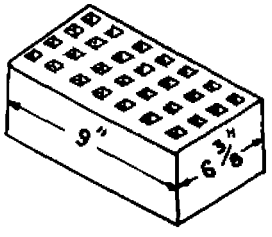
Modern Kiln

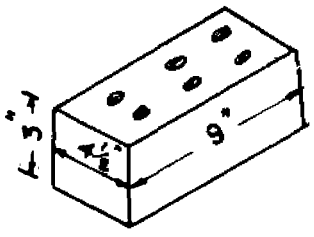
The advantages of Bull's trench kiln and Hoffman's kiln have been combined into a new design of kiln which is called Modern Hoffman's kiln. Even temperature inside the kiln and low consumption of fuel which result in proper burning of bricks at low cost are the special features of this kiln. Like the Hoffman kiln, this kiln has a permanent chimney. The shape of this kiln resembles that of Bull's kiln. In the Modern Hoffman Kiln there is a middle wall on both the sides of which there are trenches as are there in the case of Bull's kiln. With the help of permanent walls which have parchment doors, the kiln is divided into different compartments. The fire advances from one compartment to another by the burning of parchment and in this manner when bricks in one chamber have burnt, those in another start burning. For making the work of loading of the kiln easier, the kiln is constructed on the ground. Proper controls are provided for maintaining even temperature in the kiln. This kiln can be used for burning bricks all the year round and is very economical in use.

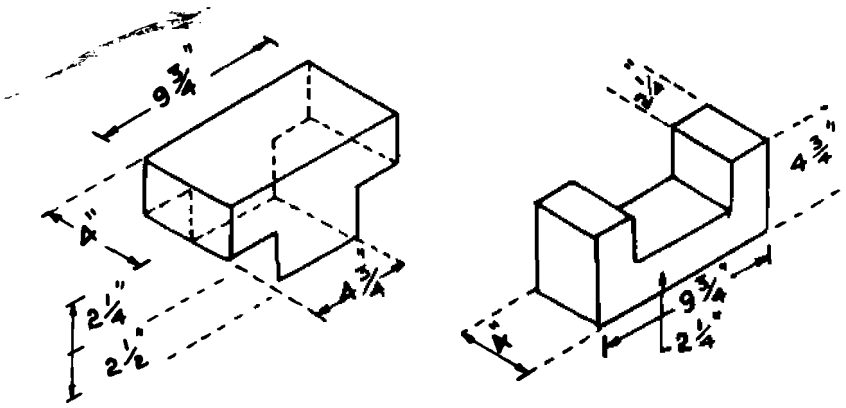
Some details of the Modern Hoffman's kiln are given in the sketch.

NEW TYPE OF BRICKS

By studies and investigations new types of bricks such as hollow bricks, perforated bricks, tee and channel bricks which are shown below have been invented. Each of these bricks has its own advantage and therefore these should be manufactured according to the requirements.







Standard Brick

The Indian Standards Institution, New Delhi has specified 19×9×9 cm. bricks (the size of which with mortar joint becomes 20×10×10 cm.) as a standard brick. The minimum compressive strength of the standard brick has been specified to be 35 k.gm. per sq. cm. With the studies and experiments carried out by the Indian Standards Institution it has been found that manufacture of 19×9×9 cm. standard brick would not present any difficulty. This standard brick is very useful in practice as it also fits in the modular planning.

BRICK KILN CO-OPERATIVES

The work of manufacturing bricks through the brick kiln co-operatives has proved to be profitable. About 772* brick kiln co-operatives have been established in Uttar Pradesh. In these co-operatives some 55,000 people have been working and they have produced more than 97 crores of bricks which cost about Rs. 1.95 crores annually. It has been said that the cost of bricks produced by these co-operatives is about Rs. 15.50 to Rs. 17 per 1,000. It has been estimated that one unit of the co-operative could produce economically 10 lakhs bricks annually. In this manner through the co-operative societies depending upon the local requirements, the required quantity of bricks could be produced at low cost. It is therefore thought that such brick kiln co-operatives could also be started in other parts of the country.

* Based on figures of 1957.

ALL INDIA BRICK MANUFACTURERS' ASSOCIATION

Generally brick manufacturers have to face difficulties of similar nature such as obtaining requisite quantity of coal for brick burning, the problem of its transportation, improvement in the quality of bricks, possibilities of use of machines for brick making, modernisation of brick industry, application of results of researches in the brick industry, etc., etc. Almost in every part of the country bricks are being manufactured and in some States brick manufacturers' associations are existing; yet this industry is not well organised. All India Association of Brick Manufacturers, it is thought, would be a very useful organisation. Such an all India organisation would work in close collaboration with the different State associations and as such it would be able to take up the problems confronting the brick industry on a national scale for their solution, particularly the problems such as obtaining requisite quantity of coal and its transportation, promotion of the use of bricks in construction, etc.

The idea to have an All India Brick Manufacturers' Association was put forth by the N.B.O. at the symposium on Brick Manufacture in India organised by it in 1957 at Calcutta. At this symposium a sub-committee was formed which has framed the rules and regulations for an All India Association with the help of the National Buildings Organisation. An All India Brick Manufacturers' Association has since come into being.

FILM ON BRICK MAKING

Based on this book a film on Brick Making has been produced by the Films Division, Government of India, under the technical direction of the National Buildings Organisation. Prints of the film in 16 or 35 m.m. with commentary in English or Hindi or any other Indian language could be obtained from the Controller of Films, Films Division, Government of India, Peddar Road, Bombay. The film is about 600 meter (2,000 feet) in length and of about 15 minutes running time.

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REGIONAL LANGUAGE EDITIONS OF 'BRICK MAKING'

Language editions of 'Brick Making' are being brought out in Assamese, Bengali, Gujarati, Kannada, Malayalam, Marathi, Oriya, Punjabi, Tamil, Telugu and Urdu. The Hindi edition is being reprinted.

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